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DEVELOPMENT OF RENEWABLE ENERGY THROUGH HEAT ENHANCEMENT FOR LUBRICANTS BY ADDING NANO MATERIALS

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ABSTRACT

Industrial machines' efficiency mostly depends on its crucial components performance in many naval applications such as hydro plants, ships, vehicles and power generation stations etc., depending on reliability and safety. It is easy to reduce various impacts by changing the way and category of lubricants being used. Selection of the proper lubricant (s) is an art, and it sharply minimizes long-term costs as well performance of components. This analysis was focused about thermal conductivity (k) for Nano fluids of Fly Ash, SiO2, Al2O3 and a biological material (material is extracted from plants and the same is used by our ancients in various applications as lubricant additive). The nano particles' size and characteristics were measured by electron microscope scanning (SEM). The maintenance activities for several cases also have considerable environmental impact, and they must have environment friendly approach. Proper selection of well suited base stocks as well additives reduces environmental impact. The paper presents 3 different types of lubricants and they are used to examine their thermal properties, which greatly effects on performance of components. Synthetic oil, SAE 0W-20 is experimentally and analytically examined for several configurations, and data collected is calculated and compared. This analysis can provide the information and assists in the selection correct lubricant additive with minimized environmental effects. Extensive research revealed that heat transfer capacity for materials depended on thermal conductivity (k). And, an advanced technology facilitated nano fluids' usage for further improvement in thermal conductivity.

KEYWORDS: Al2O3; Fly Ash; Thermal Conductivity; Biological Material & Nano Fluids

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NOMENCLATURE

nm	nanometers
µm	micrometre
P	Poise
cP	centi Poise

ABBREVIATIONS

ASTM	American Society for Testing and Materials

CFD Computational Fluid Dynamics

CNT Carbon-Nano Tube

EHL Elasto Hydrodynamic Lubrication

EP Extreme Pressure

MWCNT Multi Walled Carbon Nano Tube

SAE Society of Automotive Engineers

SEM Scanning Electron Microscopy

TEM Electron Microscopy Transmission

LMTD Log means temperature Difference

OHTC Overall heat transfer Coefficient

1. INTRODUCTION

The major purpose of lubricants is to reduce friction between mating parts by absorbing generated heat, and the same heat needs to be transferred to the surroundings as quick as it receives. The result of such action protects components from overheating, and as such components life, efficiency and performance increases. Several extensive investigations were done by researchers for minimizing the component size, to reduce the cost and for other parameters. Heat exchangers are heat transfer devices which transfer heat energy, which is stored as internal energy in the particles to other particles; This HE is important device for industries and domestic applications in heating and cooling process such as transportation industries, power plants, air-conditioning, petroleum refineries, refrigeration, cryogenic applications, heat recovery elements and others. Heat exchange plays major role in addition to above applications like manufacturing, metal cutting, production industries and lubrication sector. The LMTD and OHTC (U) concepts are used in design and analysis of heat exchangers.

Afzal et al (2017) [1] experimentally found that boron nitride having good stability, thermal conductivity and frictional properties for micro and nano size particles. N.N.M. Zawawi et al (2018) [2] has done experimentations on viscosity and thermal conductivity on different nano composite lubricants with addition of 0.02% and temperatures range of 30 to 80^oC. The obtained enhancement ratio for Al2O3-SiO2/PAG based is about 0.68% to 1.035%. The viscosity is the order of 1.012 to 9.79%. Ajay Vasishth et al., (2014) [3] did experimentation on Industrial Lubricants rheological parameters. These parameters influence on lubricant properties like friction, viscosity etc. They derived relation for viscosity and temperature for single and multi-grade lubricant oils like SAE20W-50, MC20W-50, DXTIII, MG20W-50 and EP90. David W. Johnson et al., (2013) [4] has conducted experiments on Phosphate Esters, as well as Thiophosphate Esters, and finally on Metal, Thiophosphates used as Lubricant Additives and gave detailed knowledge on recent development. This study revealed that phosphate and thiophosphate esters have anti-wear properties even in extreme pressure conditions. This work includes usage of alkyl, triaryl phosphates and thiophosphate esters, which consists metal elements. The working mechanisms of above materials when comparing with a wide range of iron as well steel based materials are examined. According to Selby T.W (2000) [5], If the sheer stress, pressure and temperature need for lubricants increased, and then more additives need to be developed. In other aspect, the environmental requirements

created more need for metal free additives and additives with little or no phosphorus and sulfur content. The phosphorus is containing many organic metal esters developed to fill many number of things. If the used phosphorus concentration decreases, then the phosphate esters, which are more effective at lower concentrations. And, if we consider non phosphorus additives, the effect was increased. The literature reviled that the phosphorus concentration for both in the oil and its volatility does not predicted phosphorus emissions. Krim et al (2002) [6] experimented on solid-liquid nano composite fluids. These are a mixture of nano metallic particles with different sizes in the range of 1 to 100 nm, suspended in base fluid. Choi (1999) [7] explored suspended nano metallic fluids thermal conductivity; found that these possesses excellent conductivity than conventional fluid. The analysis showed significant drawback on sedimentation of particles, pressure drop and friction of these suspended particles. M.K.A. Ali et al (2016-18) [8-10] did enhancement on thermo physical properties like viscosity and thermal conductivity for lubricating oil with addition of nano-lubricants. The nano particles of Al_2O_3/TiO_2 are suspended in 5W-30 oil of 8-12nm size with 0.25% weight. The obtained values resulted in low kinematic viscosity with index by 2%. For temperature 10–130 °C, the thermal conductivity was improved by a 12–16% and minimization of friction coefficient about 40–50%. The results showed, nano-lubricants can improve torque, efficiency, and brake power and fuel economy for engines. But, the bsfc is greatly reduced with 1.7-2.5% when compared without nanoparticles. The graphene nano lubricants are induced wear and anti-friction properties by 22-35%, exhaust emissions reduced by 2.79-5.42% viz., CO2, HC, CO, and NOx with reference oil. Spikes, H (2004) [11] discussed on Current limits on environmental effects for phosphorus as well as sulfur in lubricant formulations and heavy metal emissions, which is more threatening to the use of ZDDP, for engine oil. These things have brought in an increased interest in research, to find replacements for non-phosphorus materials. The history and early research about ZDDP was reviewed by Spikes. Kavitha et al [12] did research work on nano fluids synthesis by suspending nano particles in liquid of ~6 nm Tio2 powder. Sol-gel technique is used to test nano particles properties and characterized by XRD and SEM. Jianqang et al (2012) [13] used lubricant additive dialkyl-dithio phosphyl phosphate with different alkyl groups. To analyze tribological effects, a 4-ball tester with different loads for mineral base oil is used and results compared with commercial additives. The results shows that, these materials have excellent load-bearing capacity and good anti wear properties than commercial additives. Boris et al (2013) [14] studied effect of adding additives to lubricants in nano form. For this purpose, ultra-dispersed acid and PTFE is considered as nano materials. The advancements in nano materials like engine oils, greases, and industrial lubricants are studied and concluded that, adding nano materials enhance the lubricating properties. Jiao et al., (2011) [15] prepared notes on Al_2O_3/SiC composite material with nano-lubricants and established a relation to reduce coefficient of friction than pure Al_2O_3 and SiC nanoparticles. Afzal et al (2017) [16] experimentally found that boron nitride having good stability, thermal conductivity and frictional properties for micro and nano size particles. Guptha H.K. et al (2012) [17] made an overview of nano fluids as applied to additives in gear lubricating oils. They are basically heat transfer fluids. They concluded that a small percentage addition of nano particles has the potential to increase thermal properties for lubricants. The various parameters that influence the application of nano particles and several challenges for development were outlined by them. The major issues are stability of nano fluid and its production cost. The major problems with nanoparticle are erosion, settling and aggregation. Kareem Gouda et al (2013) [18] made Studies on addition of nano particle in the performance of intermediate gearbox lubricant for AH-64. The evaluation of the dynamic viscosity and thermal conductivity for Mobile AGL Oil (product from AGL Energy Services, publicly–listed Australian company) was enhanced in this paper. Mohan Kumar et al (2017) [19] evaluated nano-lubricants tribological properties and its applications like machines, engines and other components. The lubricating oil, which contains nano particles are affected on its wear, thermal, friction, physical and chemical properties in multiple ways. This study reported on effects of TiO2 nanoparticles when suspended in

lubricating oil (servo system), prepared by sonication process. Four different concentrations are used by volume (0.2% - 0.8% in steps of 0.2 %) for nanoparticles of TiO_2. They are used in the base lubricating oil for analysis. This paper investigated physicochemical properties like viscosity, Calorific value and flash point for TiO_2 nano-lubricant. The results showed that, the values are decreasing with increasing VCs when compared with base lubricant. In other hand, the Viscosity is same with base lubricant oil. Whereas, friction coefficient and wear scar diameter were increased with increase in VCs. M. E. Ashour et al (2016) [20] worked on different materials like SiO_2, Fe, TiO_2, Cu, LaF_3 nanoparticles etc. These are used to analyze tribological properties for prepared nano-lubricants in the machines, engines and other moving components. The improvement was observed in frictional properties with these nano-lubricants, and also thermal conductivity is improved.

2. EXPERIMENTAL PARAMETERS

The components for experimental set-up includes horizontal pipe in pipe (copper pipes- are having high thermal conductivity) test section, hot lubricating oil tank, pumps, cold-water tank, Rota meters and bypass valves etc. The selection of instruments is done according to accuracy, availability and measuring range available in the market. To achieve any good particular engineering problem, a set of principles are need to follow for proper and better economic product development. These economics influence selection and design of good equipment. Out of different types of heat exchangers, concentric pipe type heat exchanger possesses good features in its simplest form, good heat transfer etc. In this type of HE, one fluid (hot or cold) flows in inner pipe and other fluid (hot or cold) flows through annulus space for both the pipes. The fluids may be parallel or counter flow. Of course, the counter flow HE have higher heat transfer rate compared to parallel flow HE for same surface area. Several parametric values are assumed for design purpose, and iterations are made to optimize various values. The figure 1 shows the fabricated concentric pipe HE, which is designed and fabricated, based on above concepts for the experimentation and experimental data collection.

Figure 1: Experimental Set Up

Let mhot=hot fluid flow rate in LPM; L = length of the inner pipe in m; Di= pipe inner diameter in m; Vfluid =volume of fluid in ml; mcold=cold fluid flow rate in LPM; Cpc = specific heat of cold fluid in KJ/kg K; U= overall heat transfer coefficient in kW/m2C; mc =cold fluid in kg/sec; Cph =specific heat of hot fluid in KJ/kg K; Th, in= hot fluid inlet temperature in °C; mh=hot fluid in kg/sec; As = Surface Area in m²; Cc =Heat capacity of cold fluid in kW; Tc,in= cold fluid inlet temperature in °C; Ch =Heat capacity of hot fluid in kW; Cmax= Maximum heat capacity in kW; C =Capacity Ratio = Cmin/Cmax; Cmin= Minimum heat capacity in kW; Qmax = maximum heat transfer in kW; NTU= number of transfer units; Q actual= actual heat transfer in kW; ε = Effectiveness; Tc,out= cold fluid outlet temperature in °C; Th,out= hot fluid outlet temperature in °C; Thi-Tho= hot fluid temperature difference in °C; LMTD= log mean temperature

difference; Tco-Tci= cold fluid temperature difference in °C; ϱ=density of oil, kg/m3; Q= discharge, m3/s; ν=kinematic viscosity, m2/s; Ac=cross sectional area, m2; Re=reynolds number; f=friction factor; V=velocity, m/s; hf=pressure drop due to friction, bar.

Table 1: Selection of Parameters and Values

S.No	Constant parameters	Values
1	Di	0.008
2	m_{cold}	2
3	m_{hot}	3
4	U	0.2
5	Cpc	4.178
6	Cph	2.219
7	Th,in	100
8	Tc,in	30
9	mc	0.0333
10	mh	0.042
11	Cc	0.1393
12	Ch	0.0932
13	Cmin	0.0932
14	Cmax	0.1393
15	C	0.6692
16	Qmax	6.5239

S.No	parameter	1	2	3	4
1	L	1	1.5	2	2.5
2	V_{fluid}	50.24	75.36	100.48	125.6
3	As	0.0251	0.0377	0.0502	0.0628
4	Q actual	0.3365	0.4941	0.6452	0.7902
5	NTU	0.0539	0.0809	0.1078	0.1348
6	ε	0.0516	0.0757	0.0989	0.1211
7	Th,out	96.3891	94.6979	93.0768	91.5214
8	Tc,out	32.4164	33.5482	34.6331	35.6739
9	Re	398.0891			
10	h_f	0.0836	0.1254	0.1672	0.209

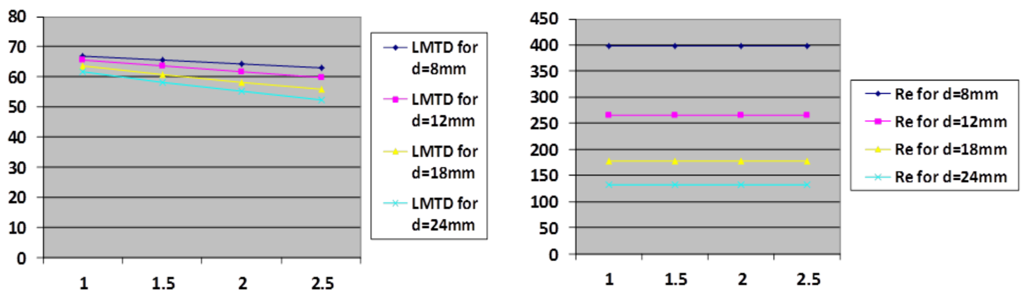

Figure 2: Variation of LMTD, Re along the Length and Diameter

The table 1 shows the selected parameters like heat capacities, Specific heat, OHTC, flow rates etc., for the diameter of pipe 8mm and their corresponding values. And figure 2 represents, if the diameter of pipe decreases the LMTD increases, results in greater heat transfer. In other hand, as the diameter of pipe increases, Reynolds number decreases may cause flow obstruction. Hence, from the discussion we can conclude that the preferable optimal diameter of inner pipe is 8mm or 12mm and length is 2m.

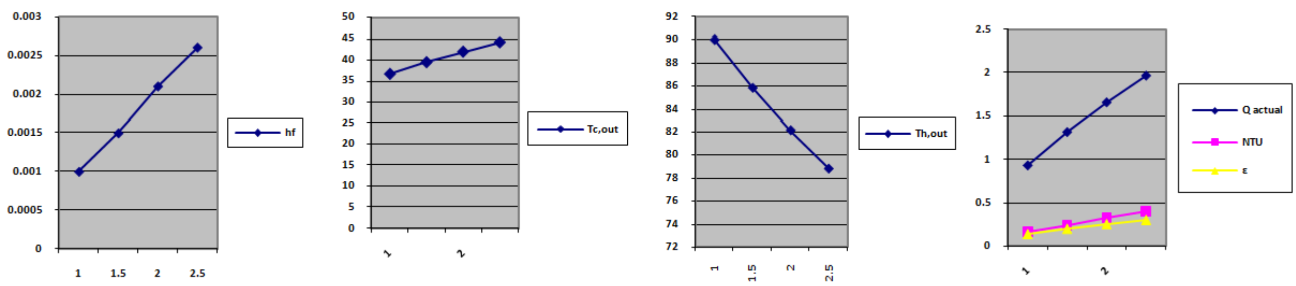

Figure 3: Variation of hf, Tcout, Thout, NTU and Effectiveness along the Length

From the figure 3, it is understood that, when the diameter of pipe is 8mm (constant), if the pipe length increases, the heat transfer, effectiveness, NTU and pressure drop also increase. On other hand, hot fluid temperature decreases and cold fluid temperature increases.

Conclusion

From the above diagrams, tables and discussion, we can understand that even if there is more temperature difference, pressure drop exists between fluids, it is necessary to have flow as more as possible for proper flow sustainment in the pipe. So, it was concluded by compromising the other things, the dimensions for inner pipe inner diameter is 8mm and length of pipe is 2m.

3. DATA COLLECTION AND CALCULATION PARAMETERS

The various properties of the lubricants measured in this experiment and presented in this paper, are as follows.

- Viscosity (µ)
- Flash and fire points
- Specific gravity (SG)
- Coefficient of friction (Cf)
- Specific heat (Cp)
- Heat transfer coefficient (h)
- Thermal conductivity (k)

The sample calculation (s) for various parameters viz., Viscosity (µ), Flash and fire points, Specific gravity (SG), Coefficient of friction (Cf), Specific heat (Cp), Heat transfer coefficient (h), Thermal conductivity (k) are presented for Fly Ash at 0.4% from tables 2 to 8.

Table 2: Estimation of Density and Viscosity for 0.4% of Fly Ash

S.NO		Temperature of oil	Time of collecting 50ml of oil	weight of measuring jar	weight of measuring jar + 50cc of oil	mass of oil	volume of oil	density of oil	kinematic viscosity	Dynamic Viscosity
	symbol	T	t	W1	W2	m	v	ρoil	$V x10^{-6}$	µ
	units	℃	sec	gms	gms	gms	cc	kg/m3	m2/s	N-s/m² or Pa-s
	relation					[W2-W1]		[m/v]	[At-(B/t)]	[=ρ*V]
1		40	982	17.17	58.83	**41.66**	50.1	**832**	**242.4878**	**0.2016**
2		60	692	17.17	58.83	**41.66**	50.7	**822**	**170.8301**	**0.1404**
3		80	344	17.17	58.83	**41.66**	51.5	**809**	**84.7790**	**0.0686**
4		100	196	17.17	58.83	**41.66**	51.7	**806**	**48.0804**	**0.0387**
5		120	102	17.17	58.83	**41.66**	53.6	**777**	**24.5567**	**0.0191**
6		140	86	17.17	58.83	**41.66**	54.1	**770**	**20.4947**	**0.0158**

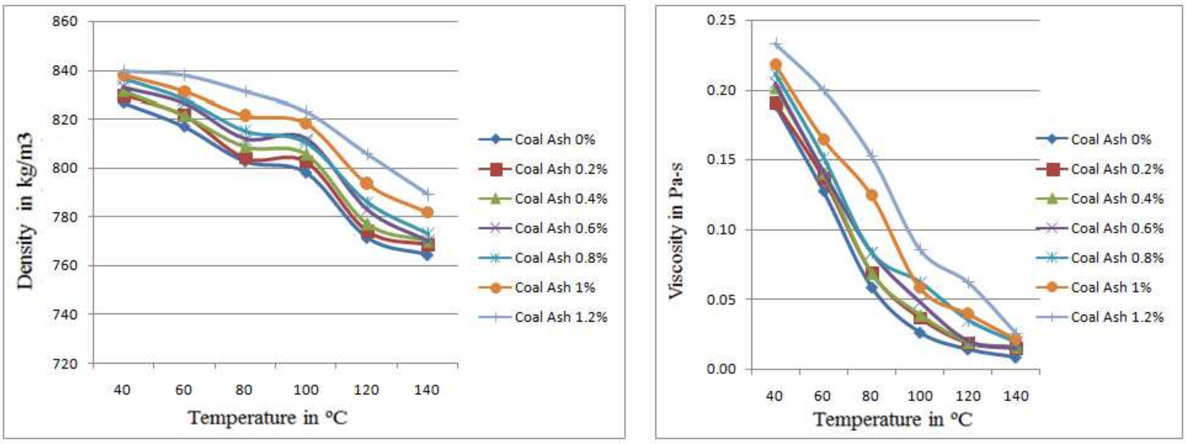

Figure 4: Density and Viscosity for Fly Ash at Different Concentrations

The table 2 represents the estimation of viscosity and density for Fly Ash, added with 0.4% in nano form, presented as a sample calculation. It was observed that, as the temperature increases, both viscosity and density decreases. The experimental data was collected by using redwood viscometer1. Figure 4 represents comparison of Viscosity and Density for Fly Ash at different concentrations as mentioned. If the addition of coal ash percentage increases, its density and viscosity also increases. Hence, adding nano material is limited, since which greatly effects on various parts.

Table 3: Estimation of Flash and Fire Points for Fly Ash at Different Concentrations

S.NO		Material	%	Flash point	Fire point
	symbol			T	T
	units			℃	℃
1		Coal Ash	0	208	212
2			0.2	208	216
3			0.4	210	218
4			0.6	211	221
5			0.8	215	220
6			1	218	222
7			1.2	219	224

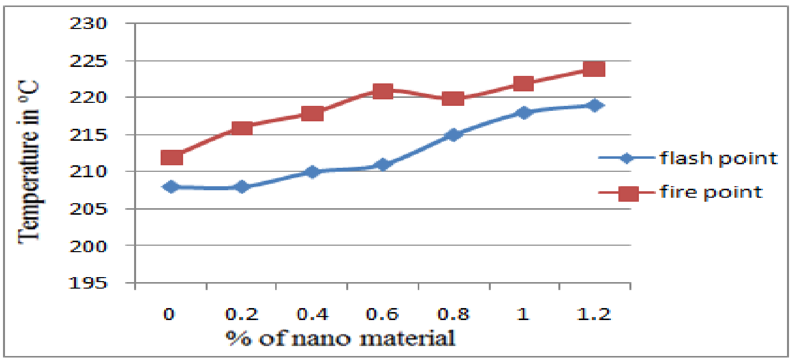

Figure 5: Flash and Fire points for Fly Ash at Different Concentrations

The table 3 represents the data collected for Fly Ash, for both flash and fire points at different concentrations. Figure 5 shows the comparison of flash, and also fire points at different concentrations. It can observe that, as the addition of nano material increases, both flash and fire points increases. The data was collected by using Cleveland's flash and fire point apparatus.

Table 4: Sp Gravity for Fly Ash at Different Concentrations

S.NO		Temperature of oil	density of oil	density of water	specific gravity
	symbol	T	ρ_{oil}	ρ_w	SG
	units	℃	kg/m3	kg/m3	
	relation				ρ_{oil}/ρ_w
1		40	**832**	**1000**	0.8315
2		60	**822**	**1000**	0.8217
3		80	**809**	**1000**	0.8089
4		100	**806**	**1000**	0.8058
5		120	**777**	**1000**	0.7772
6		140	**770**	**1000**	0.7701

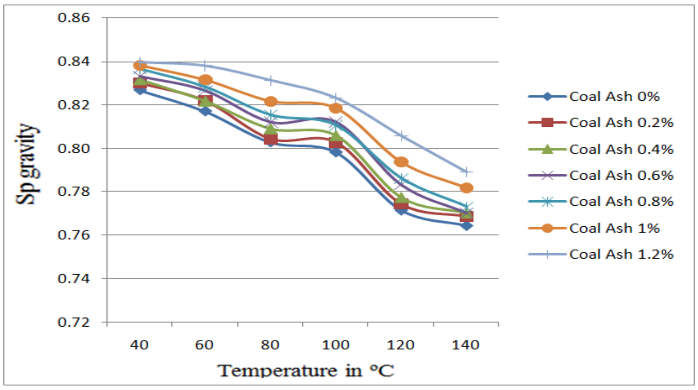

Figure 6: Sp Gravity for Fly Ash at Different Concentrations

The table 4 represents the estimation of specific gravity for Fly Ash, added with 0.4% in nano form. It was observed that, as the temperature increases, specific gravity decreases. Figure 6 represents comparison of specific gravity for Fly Ash at different concentrations, as mentioned. If the addition of coal ash percentage increases, its specific gravity also increases.

Table 5: Estimation of Friction Coefficient for 0.4% of Fly Ash

Temperature of oil	manometer reading	density of mercury	pressure drop	volume flow of oil	Velocity of oil	density of oil	Darcy friction factor	friction coefficient
T	h	ρ_{mer}	ΔP	Qoil	Voil	ρoil	f	Cf
℃	m	kg/m3	N/m2	m3/s	m/s	kg/m3		
			ρgh		Qoil/A		(2*d*ΔP)/(L*ρoil*V²)	f/4
40	0.0226	13500	2993.0310	**0.0000025**	**0.0498**	**831.5369**	**11.6335**	**2.9084**
60	0.0198	13500	2622.2130	**0.0000025**	**0.0498**	**821.6963**	**10.3143**	**2.5786**
80	0.0192	13500	2542.7520	**0.0000025**	**0.0498**	**808.9320**	**10.1595**	**2.5399**
100	0.0159	13500	2105.7165	**0.0000025**	**0.0498**	**805.8027**	**8.4460**	**2.1115**
120	0.0137	13500	1814.3595	**0.0000025**	**0.0498**	**777.2388**	**7.5449**	**1.8862**
140	0.0116	13500	1536.2460	**0.0000025**	**0.0498**	**770.0555**	**6.4479**	**1.6120**

Table 6: Estimation of Specific Heat for 0.4% of Fly Ash

S.NO		Temperature of oil	hot fluid inlet temp	hot fluid outlet temp	cold fluid inlet temperature	cold fluid outlet temperature	hot fluid flow rate	cold fluid flow rate	specific heat of water	heat transfer rate	specific heat of oil
	symbol	T	Thi	Tho	Tci	Tco	mh	mc	Cpw	Q	Cp oil
	units	℃	℃	℃	℃	℃	kg/s	kg/s	J/kgK	W	J/kgK
	relation									mc*Cpw*(Tco-Tci)	Q/(mh*(Thi-Tho)
1		40	38.9	33.6	33.3	34.5	**0.0021**	**0.0042**	**4178**	**20.89**	**1899.7962**
2		60	59.1	36.4	34.3	39.4	**0.0021**	**0.0042**	**4178**	**88.78**	**1907.6819**
3		80	76.5	40.7	34.5	42.6	**0.0020**	**0.0042**	**4178**	**141.01**	**1955.1967**
4		100	95.7	50	35	45.7	**0.0020**	**0.0042**	**4178**	**186.27**	**2031.1072**
5		120	114.9	55.4	34.9	48.5	**0.0019**	**0.0042**	**4178**	**236.75**	**2055.4274**
6		140	134.8	63.4	34.9	51.2	**0.0019**	**0.0042**	**4178**	**283.76**	**2071.9876**

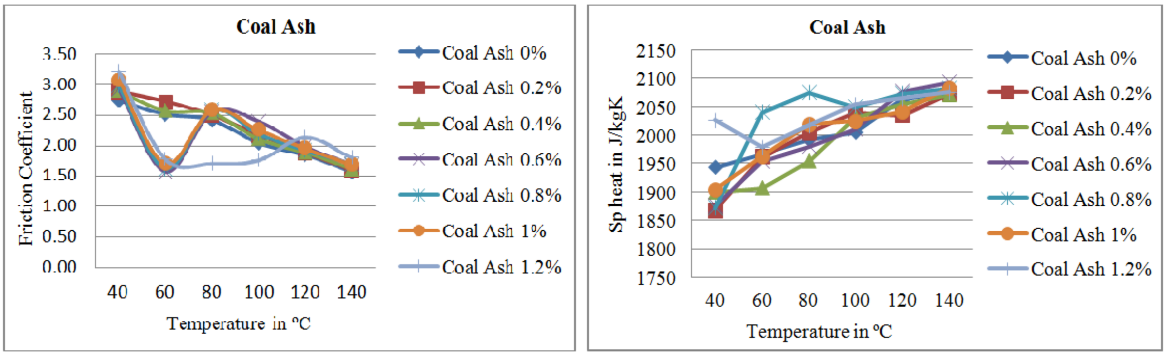

Figure 7: Friction and Specific Heat for Fly Ash at Different Concentrations

The table 5 and 6 represents the estimation of Friction and Specific heat for Fly Ash, added with 0.4% in nano form, presented as a sample calculation. It was observed that, as the temperature increases, Friction decreases whereas Specific heat increases. Figure 7 represents comparison of Friction and Specific heat for Fly Ash at different concentrations, as mentioned. If the addition of coal ash percentage increases, it's Friction and Specific heat increases or decreases based on percentage.

Table 7: Estimation of Heat Transfer Coefficient for 0.4% of Fly Ash

	Temperature of oil	hot fluid inlet temp	hot fluid outlet temp	cold fluid inlet temperature	cold fluid outlet temperature	temp diff between hot fluid inlet & hot fluid outlet	temp diff between cold fluid inlet & cold fluid outlet	heat transfer rate	convective heat transfer coefficient
symbol	T	Thi	Tho	Tci	Tco	ΔTh	ΔTc	Q	hi
units	℃	℃	℃	℃	℃	℃	℃	W	W/m2K
relation						Thi-Tho	Tco-Tci	mc*Cpw*(Tci-Tco)	Q/(ΔTh*Ai)
	40	38.9	33.6	33.3	34.5	5.3	**1.2**	**20.8900**	**78.4536**
	60	59.1	36.4	34.3	39.4	22.7	**5.1**	**88.7825**	**77.8488**
	80	76.5	40.7	34.5	42.6	35.8	**8.1**	**141.0075**	**78.3988**
	100	95.7	50	35	45.7	45.7	**10.7**	**186.2692**	**81.1288**
	120	114.9	55.4	34.9	48.5	59.5	**13.6**	**236.7533**	**79.2008**
	140	134.8	63.4	34.9	51.2	71.4	**16.3**	**283.7558**	**79.1037**

Table 8: Estimation of Thermal Conductivity for 0.4% of Fly Ash

S.NO		Temperature of oil	Nusselt number	heat transfer coefficient	thermal conductivity of fluid
	symbol	T	Nu	hi	k_{nf}
	units	℃		W/m2K	W/mK
	relation		constant heat flux		(hi*d)/Nu
1		40	4.36	78.4536	0.1440
2		60	4.36	77.8488	0.1428
3		80	4.36	78.3988	0.1439
4		100	4.36	81.1288	0.1489
5		120	4.36	79.2008	0.1453
6		140	4.36	79.1037	0.1451

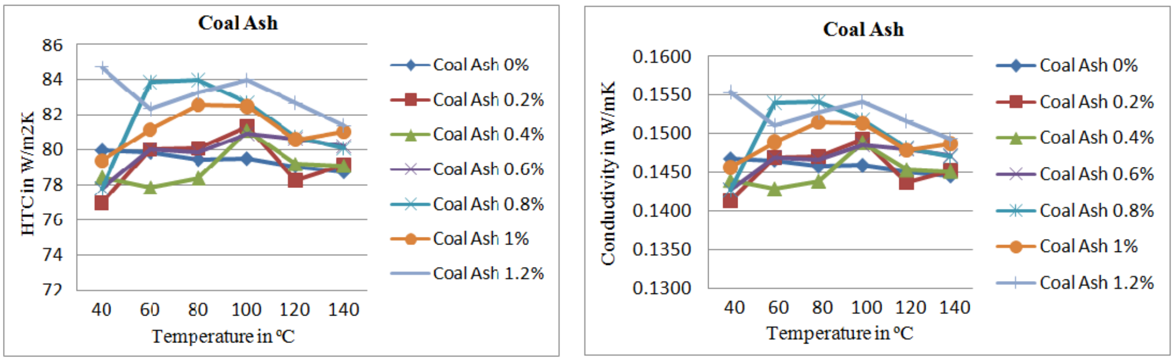

Figure 8: HTC and Thermal Conductivity for Fly Ash at Different Concentrations

The table 7 and 8 represents the calculation of HTC and thermal conductivity for Fly Ash, added with 0.4% in nano form. From table, as the temperature increases, HTC and thermal conductivity decreases/increases. Figure 8 represents comparison of HTC and thermal conductivity for Fly Ash at different concentrations, as mentioned. If the addition of coal ash percentage increases, it's HTC and thermal conductivity increases or decreases based on percentage. The Figure 9 shows the photo graph, taken while measuring the size of nano particles by using SEM technology.

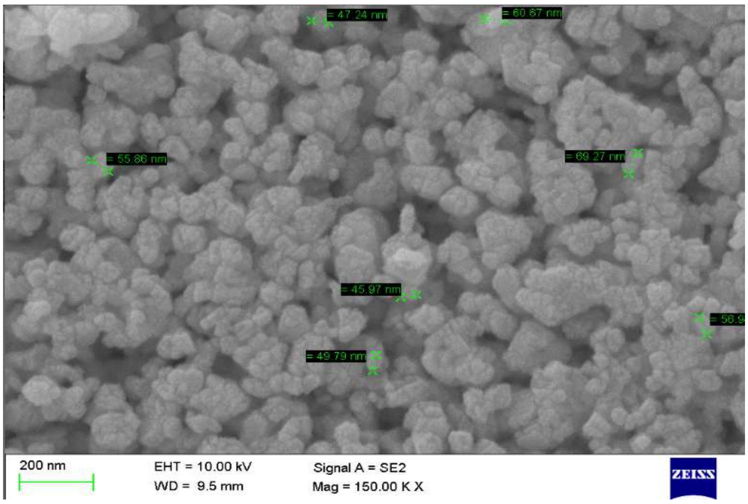

Figure 9: SEM Photograph to Measure Size

4. RESULTS AND DISCUSSIONS

From the above data, the following results were obtained and compared for nano fluids at 0%, 0.4%, 0.8% and 1.2% for Al2O3, SiO2, Coal Ash and Biological material.

4.1. Comparison of viscosity

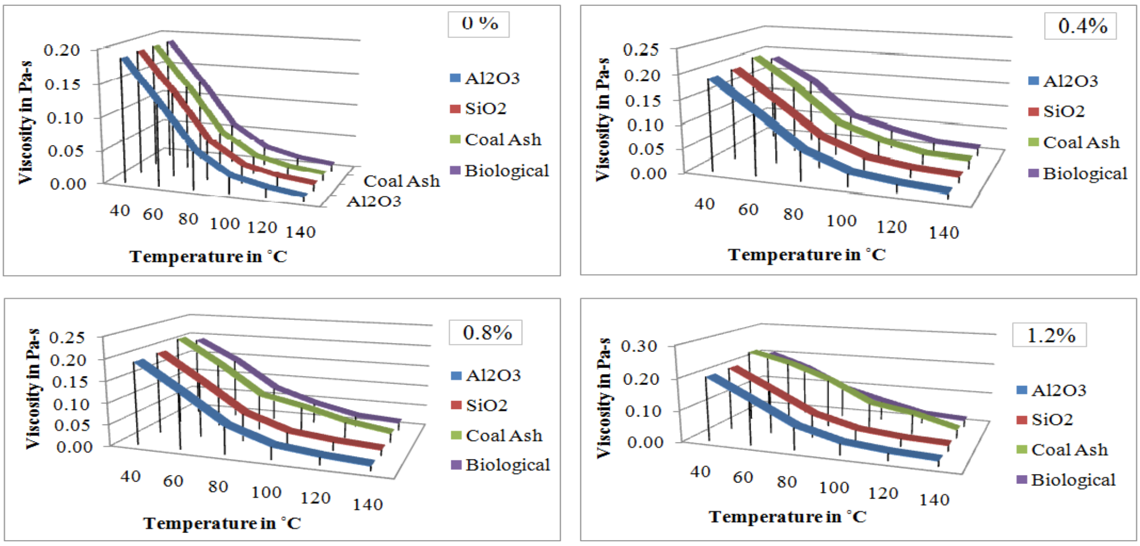

Figure 10: Comparison of Viscosity at Concentrations of 0%, 0.4%, 0.8% and 1.2%

From the figure 10, it is clear that the viscosity is more for biological material from 0.2% to 1%, after that coal ash dominates with viscosity than other materials for the temperature ranges from 40ºC to 140ºC. As the concentrations 0.2%, 0.4%, 0.6% and 1.2% are increasing the viscosity also increases for all materials. Hence, from the viscosity point of view, the addition of Al_2O_3 material is preferable than others. Because, the increase in viscosity decreases Reynolds number (by keeping the other parameters constant) causing difficulty in flow of the fluid, it also results in increase of the friction.

4.2. Comparison of Flash and Fire Points

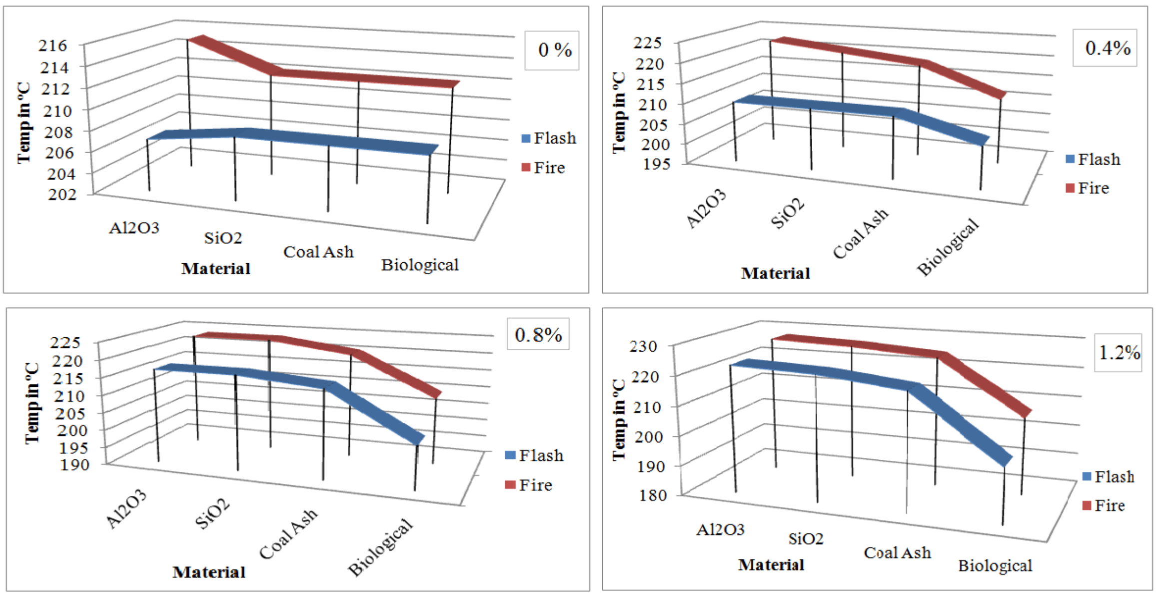

Figure 11: Comparison of Flash and Fire Points at Concentrations of 0%, 0.4%, 0.8% and 1.2%

From the figure 11, it is understand that for any given percentage of nano material, the Al2O3 have more flash and fire points compared to other materials. And, the order is Al2O3, SiO2, coal ash and Biological material, at any given temperature ranging from 40ºC to 140ºC. As the concentrations 0.2%, 0.4%, 0.6% and 1.2% increase, the flash and fire points are increasing for all materials. Hence, from the flash and fire points of view, the addition of Al2O3 is preferable than others. Because, the increase in flash and fire points is reliable for the lubricants, and it increases the operating temperatures of fluids.

4.3. Comparison of Friction

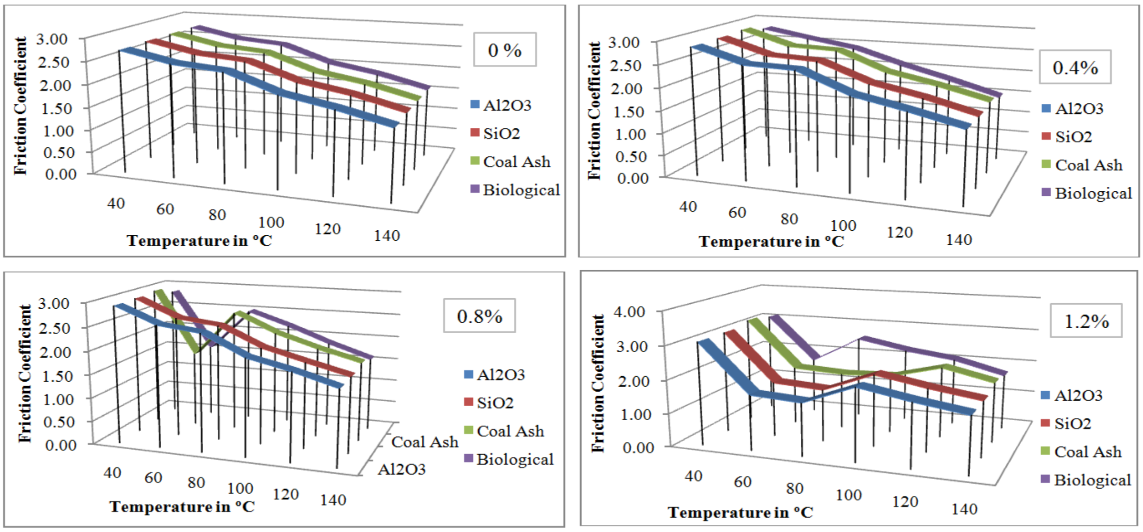

Figure 12: Comparison of Friction at Concentrations of 0%, 0.4%, 0.8% and 1.2%

From the figure 12, it is clear that the decreasing order of Friction is coal ash, SiO2, Al2O3 and Biological material at any given temperature ranges from 40ºC to 140ºC. As the concentrations 0.2%, 0.4%, 0.6% and 1.2% are increasing, the Friction also increases. Hence, in view of Friction, the addition of Biological material is preferable than other materials. The increase in Friction effects on pipe material like etching, scratching.

4.4. Comparison of Heat Transfer Coefficients

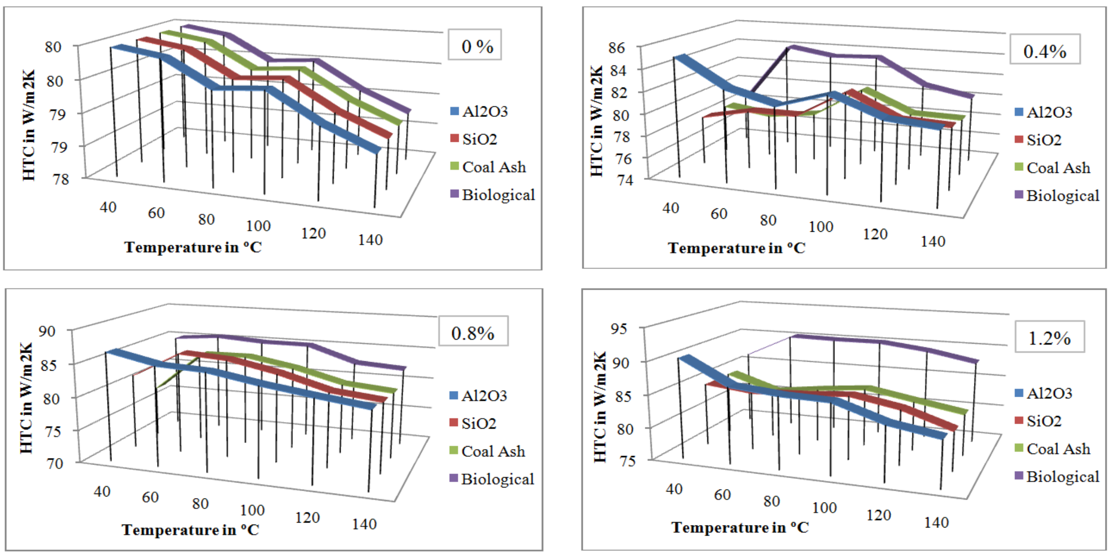

Figure 13: Comparison of Heat Transfer Coefficient at Concentrations of 0%, 0.4%, 0.8% and 1.2%

From the figure 13, it is clear that the heat transfer coefficient (htc) is more for biological material from 0.2% to 1.2%, followed by Al_2O_3 than other materials for the temperature range from 40ºC to 140ºC. As the concentrations 0.2%, 0.4%, 0.6% and 1.2% are increasing, the htc also increases for all materials. Hence, from the htc point of view, the addition of biological material is preferable than others. The table 9 shows the average values for htc at the concentrations of 0.2%, 0.4%, 0.6% and 1.2%.

Table 9: Average Values of HTC at Concentrations of 0.2%, 0.4%, 0.6% and 1.2%

	Al2O3	SiO2	Coal Ash	Biological
0.2%	82.0263	80.0582	79.3362	81.3280
0.4%	82.1458	79.7425	79.0224	81.6787
0.6%	83.4986	80.5683	79.9277	83.5526
1.2%	85.6474	83.6531	83.0642	88.9275

It is clear that the decreasing order of HTC is Al_2O_3, Biological material, SiO_2 and coal ash at any given temperature ranging from 40ºC to 140ºC. As the concentrations of 0.2%, 0.4%, 0.6% and 1.2% are increasing, the HTC for Biological material is greatly increases compared to others. Hence, from the HTC point of view, the addition of Biological material is preferable than others. The increase in HTC increases heat transfer capacity and thermal conductivity.

4.5. Comparison of Thermal Conductivity

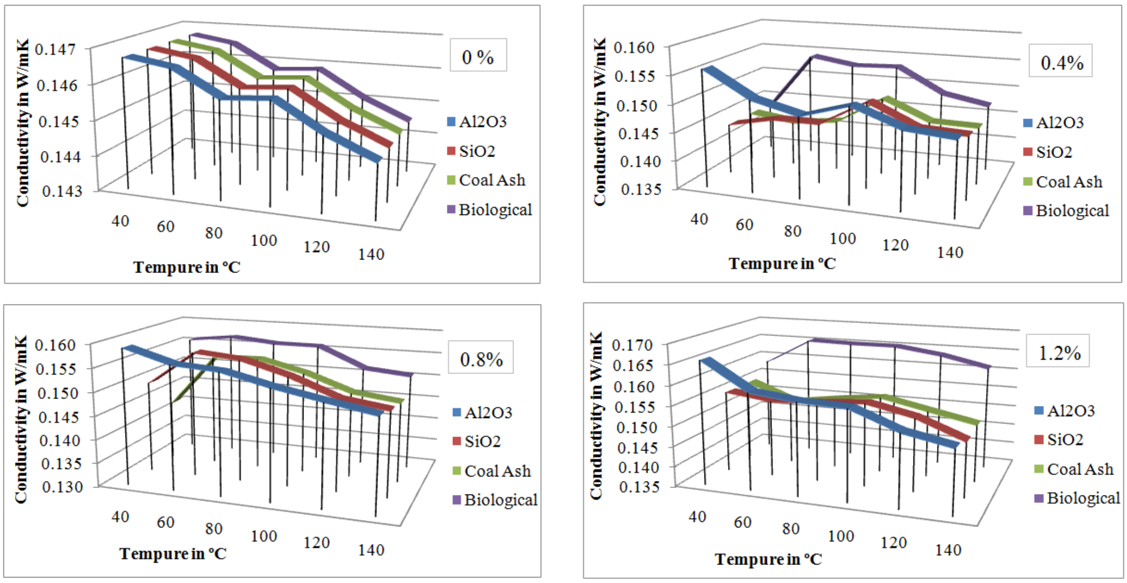

Figure 14: Comparison of Thermal Conductivity at Concentrations of 0.2%, 0.4%, 0.6% and 1.2%

From the figure 14, it is clear that the Thermal Conductivity is more for biological material from 0.6% to 1.2%, followed by Al2O3 than other materials for the temperature ranges from 40ºC to 140ºC. But from 0.2 % to 0.6%, the thermal conductivity for Al2O3 is more than biological materials. The addition 0.2%, 0.4%, 0.6% and 1.2% concentration of nano material increases, its Thermal Conductivity also rises for all materials. Hence, from the Thermal Conductivity perspective, the addition of biological material is preferable than others. The table 10 shows the average values for Thermal Conductivity at the concentrations of 0.2%, 0.4%, 0.6% and 1.2%.

Table 10: Average Values of Thermal Conductivity at Concentrations of 0.2%, 0.4%, 0.6% and 1.2%

	Al2O3	SiO2	Coal Ash	Biological
0.2%	0.1505	0.1469	0.1456	0.1492
0.4%	0.1507	0.1463	0.1450	0.1499
0.6%	0.1532	0.1478	0.1467	0.1533
1.2%	0.1572	0.1535	0.1524	0.1632

It is clear that the decreasing order of Thermal Conductivity Al2O3, Biological material, SiO2 and coal ash at any given temperature range from 40ºC to 140ºC. As the concentrations 0.2%, 0.4%, 0.6% and 1.2% are increasing, the Thermal Conductivity for Biological material greatly increases compared to others. Hence, from the Thermal Conductivity point of view, the addition of Biological material is preferable than others. The increase in Thermal Conductivity increases heat transfer capacity as well as performance of lubrication for the fluids.

5. CONCLUSIONS

The contribution of this analysis is to review research on current state of lubricating properties for lubricants in various applications, with special reference to addition of nano particles focused on use of Al2O3, SiO2, coal ash and making comparison of results obtained with Biological material for various properties for improvement of life of the components in turn machines. Results show that biological materials have a very good characteristics and excellent potential with an excellent thermal conductivity, with low friction compared to others. Hence, the addition of nano materials for lubricants increases thermal conductivity as well as heat transfer rate about 6-11% by AL2O3,-1-10% by SiO2, -2-9% by Coal ash and 5-18% by Biological Material. The scope of future work expected is unlimited in this area. More research works can be carried out towards further implementation.

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